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SPECIAL REPORT: LAN Testing

Introduction

As the local area network field matures and the number of installed LANs continues to grow, the recognition of the importance of testing and management of these networks increases. Almost six years after the publication of the Ethernet Specification V. 1.0 by Digital Equipment Corporation, Intel, and Xerox, a number of testing and monitoring devices are becoming available for use with Ethernet-type networks. These devices are transforming network installation and operation into a straightforward, deterministic procedure -- a far cry from the "hook-it-up, transmit, and pray" approach of earlier years.

This Special Report examines some of the approaches to LAN testing and monitoring. Three major areas are covered: cable testing, component testing, and network monitoring. Specific products examined are indicative of the types of LAN testing products available or under development.

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Cable Testing

In the cable area, the time domain reflectometer (TDR) is an effective and useful tool for checking the integrity of coaxial cable. TDRs now are being widely used by LAN installers and maintainers to test this critical element in the efficient operation of a network.

Currently three types of TDR-type products are on the market.

The first predates LAN technology and has been used historically to diagnose telephone cable faults: this type contains a CRT for easy visual analysis of faults, as well as a foot scrolling feature to obtain reasonably accurate distance readings. Since this technology is 20 years old, many other features needed for specific LAN use are not offered in this TDR type.

The second type of TDR has no CRT but allows the user to find dead opens and dead shorts on a network with only the foot scrolling feature. This kind of device lets users find and fix major faults but does not enable them to fine-tune their networks. Basically, problem detection is limited to the physical cable.

An example of this type of device is Riser-Bond Instruments' Model 2901B, a radar-type digital time domain reflectometer, cable fault locator selling for around $700.

The 2901B operates in two modes: the short cable mode and the long cable mode.

In the short cable mode, the 2901B will read a maximum distance of 1100 feet with one foot of resolution, or 199.9 meters with 0.1 meter of resolution. The minimum length of cable that can be tested or measured is 15 feet or 4.6 meters.

In the long cable mode, the 2901B will read out to its maximum capability of 11,000 feet with ten feet of resolution, or 1999 meters with 1 meter of resolution. The minimum length of cable that can be tested or measured is 100 feet or 33 meters.

Although the 2901B can read a maximum distance of 11,000 feet, different types of cable have different loss factors at high frequency; consequently, the cables have a shorter maximum readability.

The 2901B Digital TDR operates by transmitting a pulse, which travels down the cable until reaching either a fault or the end of the cable; the signal is then reflected up the cable to the TDR and the transit time is measured, converted to feet or meters, and displayed on the front panel LCD.

Because the TDR works on the radar principle, the cable under test must not be terminated: a terminator will absorb the TDR's pulse, and therefore no signal will return, resulting in an

all zero reading. It works best if both ends of the cable have been disconnected from all equipment.

The third type of TDR has been designed with more of the features currently required by LAN installers and maintenance personnel: this type has a CRT and foot scroller to make network fine-tuning easier than with older TDRs. Other features that are specifically useful to LAN users include inverted negative pulse, DC-coupled outputs, and collision detect simulation.

The negative pulse feature allows the TDR to be used on a powered-up network while showing the transceivers' exact impedance characteristics, and it does this without electrically damaging any transceivers. DC-coupling allows the TDR to remain resident on the network while actual data flows across it. The TDR pulse does degrade network operation by 15%, but this resulting loss is masked by software resident in each host and is therefore invisible to the network user. Collision detect simulation lets the TDR user "freeze out" all users on the network, which allows an unobstructed CRT image of the network under test.

A side benefit of this latter feature is that the TRD user is also able to detect transceivers whose collision detectors are not properly recognizing collision detection voltage levels. As the tDR tester views the CRT in this case, movement of the TDR signature may be noticed: this will indicate that packets are being sent over the network, which in turn indicates that one or more transceivers have not picked up the voltage levels.

The secret to getting good network performance lies in management and maintenance. For the TDR user, this means keeping in mind the fact that impedance changes along the cable will inhibit network throughput. To minimize these changes -- or to correct them -- the user must interpret the TDR CRT readout and locate and repair the affected hardware. Damaged or faulty LAN components can include misinstalled transceivers, abraded or kinked cable, non-conforming connectors, etc.

An example of a tester in this category is the Cabletron TDR 5000. This $4,500 device employs negative pulse technology, an approach that tests faults on both types of LANs -- baseband and broadband -- but gives special benefits to baseband, Ethernet-type networks. When testing with negative pulse, baseband networks only need to be left idle, not shut down.

Node Emulators/Testers

While TDRs give the LAN manager a good "first look" diagnosis, other products provide a greater level of detail and a more pointed analysis of problems. Examples in this category are the Cabletron LAN-MD and the TITN Experdata E20, generically called node emulators/testers.

Cabletron LAN-MD - The LAN-MD is able to check a variety of components including -- but not limited to -- transceiver

cables, transceivers, multiport transceivers, local and remote repeaters, and a host of other Ethernet-type devices. The LAN-MD employs variable-length data packets in a proprietary protocol that is invisible to users on the network, and, therefore, this device can be used on an active network without the knowledge of any of the network users. The LAN-MD then uses codes to advise the LAN manager of the network status, making detection of the problem much easier.

The LAN-MD, selling for $4,000, verifies that transceiver cables have the correct pin configuration. It checks all conductors for opens, shorts, and incorrect termination at the connectors; also, it verifies that the cable's outer and inner shields are isolated on IEEE 802.3-type cables.

Transceiver tests by the LAN-MD include testing a transceiver unit before it is installed on a network to verify correct function of circuits within the transceiver, and testing for proper transmit, receive, collision detection, power supply, fault protection, and network signal strength.

LAN-MD network tests allow the user to verify that data can be sent between any two points on a network, and to verify correct operation of repeaters, both local and remote -- this latter test however, requires two LAN-MD units.

Experdata E20 - The TITN Experdata E20 Ethernet tester/emulator is a $4,500,completely portable, easy-to-use test tool designed to allow the thorough checking of all physical elements of an Ethernet LAN.

Experdata allows system administrators to test Ethernet components, check for network and component conformance to Ethernet Version 1.0, 2.0, or 802.3 standards, measure traffic on the network, simulate different types of traffic for capacity planning and trouble- shooting, and maintain the network efficiently.

Testing with the E20 can be performed in a logical manner. First, one E-20 can be used to test either Ethernet- or 802.3-type transceiver cables: to do this, the male end of the drop cable is connected onto the tester's sub-D connector, while a loopback connector is attached to the other end of the drop cable; tests then are done to exercise the power, transmit, receive, and collision detect circuits. All transceiver cables should be tested using the E-20 before installation.

Second, transceivers can be tested/accepted before they are installed on a network. In this case, the transceiver is mounted on an Ethernet coaxial cable on one end; on the other end it is connected to the E-20 using a previously tested drop cable. During this test, data packets are sent through the transceiver to verify correct operation of the transceiver's transmitter, receiver, heartbeat, and power supply circuits. The user is able to vary the traffic characteristics by changing the frame size and/or the frame frequency. In addition, transmit and collision detect signal levels also are checked. A jabber test can be

performed to verify the proper operation of the transceiver's jabber shut-off mechanism. All transceivers should be checked before they are installed on the network.

In that the E-20 complies with all the Ethernet access and timing specifications, it also can be used to check that the transceiver and drop cable were installed correctly with both new and operational networks. A local test is performed which sends frames through the transceiver and back to the receiver circuits; here, it is checked, bit by bit, that all frames sent also are received, and that they are equal to those which have been transmitted. The E-20 also provides output connectors where signals timing can be observed using an oscilloscope.

Third, once a network has been installed, the E-20 can be used to quickly identify causes of a network problem. The problem may stem from faulty transceivers, bad coaxial cables, from a network installation (length of segments), or a device attached to the network not complying with the Ethernet norm. The network tests include transmit and receive (echo) test, collision detection test, line quality test, and round trip delay measurement.

The E-20 testers are used for all of the network tests. One of the E-20 testers is set up as a master, while the other one is set up as a slave. The echo test is used to check that frame transmission and reception occurs correctly between two nodes of the network (check of transmit and receive circuits for both transceivers). An E-20 tester (master) transmits frames of known contents over the network; the slave tester receives the frames, checks them for errors, and transmits frames back to the master tester; the master tester, in turn, verifies that the frames are received and that their contents are correct.

The collision detection test is used to verify that collision handling is effected correctly by the two transceivers under test; frames are sent by an E-20 (master) at one node to another E-20 (slave) at another node; as soon as the frame is received by the slave, it simulates a collision by sending a jam over the network, and it is then verified that the number of frames transmitted is equal to the number of collisions detected by the master tester. If heartbeat detection is on, the count is equal to twice the number of transmitted frames.

The line quality test is used to obtain a measure of line quality. While occasional collisions should be viewed as a normal part of the CSMA/CD access procedure, line errors should not. With this test, one can determine both frame and bit error rates for traffic between two nodes of the network.

The round trip delay measurement provides a value in microseconds for the amount of time it takes for a frame transmitted by a master E-20 to go to a node (where a slave E-20 is connected), and for a collision to propagate back. The 802.3 standard places very strict limits on maximum propagation times for the network segments, as well as for the total network, because these affect critical time values for the CSMA/CD access

method. For instance, one of the fundamental parameters of any Ethernet implementation is the length of the collision interval, which is based on the round-trip propagation time between the most distant points in the network.

The round trip delay measurement function can be used with only one tester to detect the location of cable anomalies (open, short, etc.) which create collisions on the network.

The E-20 tester can be used to measure traffic on a network (number of frames, number of collisions, and number of preamble errors). Furthermore, the E-20 can identify and count extensions of collision fragments to verify that collisions are transmitted over fiber optic repeaters. To evaluate the impact of added traffic in capacity planning or trouble shooting, the E-20 can generate varying degrees of traffic with frames of different sizes. Traffic generation can vary from one frame at a time to back-to-back frames (9.6 microseconds interval).

The E-20 includes seven output connectors to which an oscilloscope can be connected for visualization of signal timing: this feature is particularly useful when verifying that a piece of equipment complies with the Ethernet standard.

LAN Monitoring Devices

Network monitors are becoming popular with users of large networks since they can be used to monitor traffic levels, collision levels, retransmission rates, and utilizations, and to take other statistical measures of network activity. Two examples of the sophisticated devices in this category are the Excelan LANalyzer EX 5000E and the CMC LanScan.

LANalyzer - In February 1986, Excelan introduced LANalyzer EX 5000E, a $9,500 hardware/software package that enables an IBM PC XT, PC AT, or compatible to monitor and analyze the activity of an Ethernet (V 1.0 and V 2.0) LAN or any LAN that adheres to the IEEE 802.3 standard. Excelan also offers a version of it that is integrated into a COMPAQ Portable 286 computer for applications requiring portability such as field work.

Excelan's LANalyzer network analyzer enables network system developers to debug LAN applications and protocols, and it also allows OEMs and large end users to develop test routines for their specific LAN requirements.

LANalyzer allows the capture and analysis of data according to predefined criteria independent of protocols such as TCP/IP, DECNet, XNS, and ISO. Real-time test results are displayed in easy-to-read bar graphs and saved to an MS-DOS file for later analysis.

LAN administrators and field service engineers can use LANalyzer to troubleshoot problems on the LAN or to monitor up to 200 stations, each having user-designated names corresponding to Ethernet addresses. The ability of LANalyzer to accurately

time-stamp data within 10 microseconds of data capture allows for fine-tuning of LAN performance. Flexible start and stop triggers -- such as the appearance of a specified data packet on the LAN or the arrival of a specified hour -- enable the LAN to be monitored unattended.

A user of LANalyzer can define a range of test criteria for each of up to eight channels to simultaneously capture specific types of information about network operation; the criteria can include specific byte addresses, byte patterns, character strings, or node addresses. This capability is of considerable value to a system developer who needs such detail to verify protocols and debug problems on the LAN.

A test can be started or stopped by a single or a combination of real-time events. Events that can be used as triggers include keyboard input, packet activity on a user-specified channel, relative time, and absolute time. This feature allows for running a test unattended, which can be useful when the time of occurrence of event(s) cannot be anticipated. When the captured packets are to be saved to a disk file, the capture rate can be lower, depending on the disk speed: in such cases, some packet may be missed. In addition, the LANalyzer is capable of collecting a user-specified number of packets after a stop trigger.

Each packet is timestamped within 10 microseconds of its capture by the LANalyzer system; this information can be extremely useful in analyzing the performance of and isolating problems on a network.

The LANalyzer system has a circular trace buffer of 700 Kbytes, which allows for the capture of a large number of packets in the buffer itself; this also allows ample time for the host PC to copy packets from the buffer to the specified disk file. The LANalyzer software compares the captured packets against user-specified filters and then places the entire packets that matched the filters in the trace buffer. Optionally, the trace can be saved to an up to 10.5 Mbyte specified trace file in real time, for a later examination and analysis.

On conclusion of a test, the individual packet slices in the trace buffer can be displayed in hexadecimal and ASCII formats, side by side. Individual entries previously saved in a trace file can also be displayed in a similar fashion.

The LANalyzer system features a powerful search function that allows the user to locate and display packets of interest. A trace file can be searched for packets that contain specific byte patterns, or searched for specific errors.

Under user control, the LANalyzer system can display network statistics in real time, (see Figure), which allows for examination of network activity as it occurs. Optionally, the statistics can be stored to an MS-DOS file for later review or further analysis.

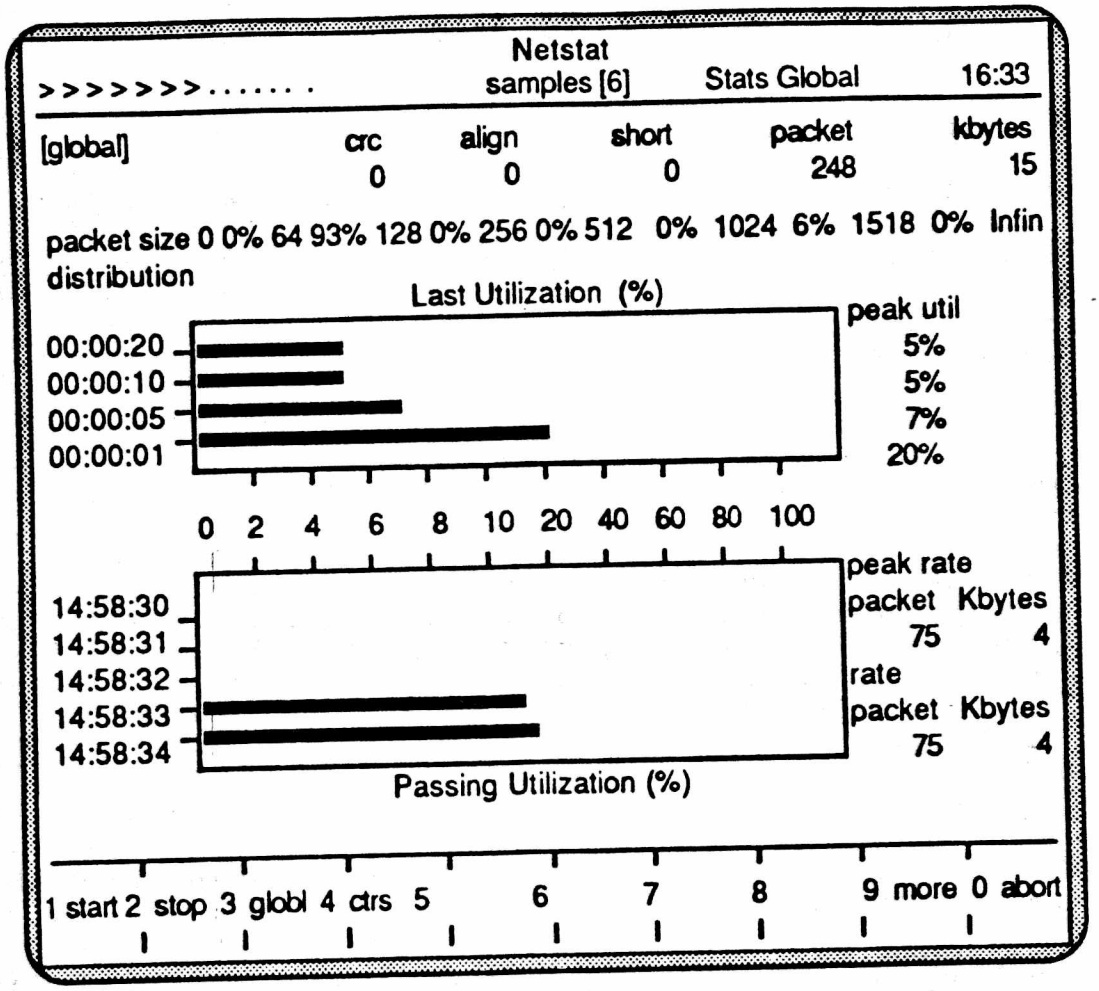

Figure: Example LANalyzer Screen

The statistics are displayed as easy-to-understand histograms and/or numeric values. The statistics information includes network and channel utilization, packet counts, error counts, packet rates, packet size distribution, total packets captured, total kilobytes captured, and counts/distribution of packets transmitted with and without collisions.

Station activity that satisfies user-defined criteria can be monitored and displayed for up to 200 stations concurrently in real time; these statistics include counts of packets received and transmitted, average packet size, and counts of erroneous packets encountered.

This feature provides information on network activity on a per station basis, which allows quick identification of problem stations.

Another important requirement for a system developer is the need to capture a precise data packet for analysis: LANalyzer provides this by capturing in its buffer up to 700 Kbytes of

traffic data in bursts and up to 1,000 packets per second on a sustained basis without missing any packets.

Excelan's LANalyzer is capable of generating controlled amounts of traffic to the network, enabling a network administrator to observe the operation of the network under various loads. This is also valuable for determining the feasibility of adding more hosts to the network. The LANalyzer also now has a cable check function to identify faults on an Ethernet cable or problems with the transceiver cable.

The LANalyzer EX 5000E implements a screen-oriented user interface. The user inputs data and commands from the keyboard. The LANalyzer system communicates with the user through two categories of displays: it uses one category of the screens for creating/editing tests and the other for displaying results.

For example, the Edit Test screen allows the specification of various control parameters for the test. Some of the control parameters are specified on the Edit Test screen itself, while others are specified on different screens accessed through the Edit Test screen.

All LANalyzer commands are executed by pressing appropriate function keys on the PC's keyboard. The commands that correspond to the function keys are displayed in a commands window at the bottom of each screen.

On invocation, the LANalyzer system displays the Edit Test screen for a default or a specified test.

A test can be run unedited or it can be edited and then run without saving it to the disk file. This means one can run several variations of a test quickly.

The LANalyzer system can also load a specified test and begin execution as soon as the start trigger is fired.

DRN-1700 LanScan Ethernet Monitor - The Communication Machinery Corporation DRN-1700 LanScan Ethernet Monitor is an $8,500, high-performance, versatile, and adaptive tool for network managers and network system developers. It attaches to an Ethernet cable and monitors traffic on the network and provides statistical information on the network's reliability. In addition to its monitoring functions, the LanScan provides a complete testing facility which is capable of assessing the general integrity of the network, as well as pinpointing specific stations on the network which may be generating errors. The monitor also supplies a means of debugging protocol-related problems through viewing network activity at the line-level.

The user controls the LanScan by entering commands at a dedicated terminal keyboard, with most commands requiring only a single keystroke. Command entry is simplified by the use of a standard set of dedicated function keys and screens with fixed menu layouts. Each menu screen displays a number of parameters, some of which may be changed. Modifiable parameters are

indicated through highlighting.

User options include the ability to designate names to represent station Ethernet addresses, so that in subsequent references the stations are denoted by names rather than by multi-digit addresses.

A printer may be attached to the LanScan's printer port in order to provide hardcopy of statistical information, test specifications, test results, and station address/name tables.

The LanScan consists of two modules: a network unit and a terminal. The network unit provides the interface to the Ethernet and performs all the data capture and formatting functions. The Terminal supplies a high-quality display screen with a separate keyboard. An interface cable connects the Terminal to the Network Unit.

The LanScan may be set to operate in any one of five "modes."

In Statistics Mode, the system displays a count of all packets sent and received, together with byte counts for every machine on the network. It also shows the number of bad packets sent by each station, which is invaluable information for measuring the reliability of the network.

The Statistics Mode is somewhat different from the other modes in that rather than causing the monitor to perform a different function, selecting it causes the monitor to display statistics that it collects at all times no matter for which mode it is set -- in other words, for as long as the Monitor is connected to the network and switched on, it collects the following information for all stations on the network: Packets Sent -- the number of packets transmitted by the station; Packets in Error -- the number of packets sent by the station which are in error when received by the monitor; erroneous packets are those with alignment errors (i.e., whose length is not a multiple of 8 bits), CRC errors, or packets that are too short (less than 60 bytes) (note that a marginal packet might appear erroneous to the monitor, but be received correctly by the target station); Packets Received -- the number of (good) packets received by the station; Bytes Transmitted -- the number of bytes in packets transmitted by the station; and Bytes Received -- the number of bytes in packets received by the station.

In Performance Mode, the system measures the intensity of each station's use of the network and also indicates total network usage. Data is presented both numerically and graphically, giving an instant picture of network activity.

In Test Mode, the LanScan uses a Time Domain Reflectometer (TDR) function to identify where on the cable a fault (either short or open circuit) has occurred. If the network seems intact but there is doubt as to whether two stations can communicate, the Monitor performs further tests designed to locate the error(s).

To do this, the Monitor sends either of two kinds of test

mechanism, as well as those which support XNS.

The Monitor performs the second set of tests by acting as a Configuration Test Server, as defined by Xerox in the Ethernet specification: in this role, it sends test packets to stations on the network and watches for echoed replies; if there is no reply from a station, it sends an ISO test packet according to the IEEE 802.2 specifications, and waits, once more, for a response.

During the running of this test, progress and error messages are output to the terminal screen.

In Development Mode, the Monitor provides a sophisticated set of packet-tracing facilities which allow network failures caused by incorrect protocol software to be readily identified. It operates by capturing data that matches PATTERNS defined by the user. The user may thereby set up trace conditions which filter out only those packets which the user believes to be causing a problem, and he or she can "trigger" the data capture to begin when some other event (also defined by the user) is detected on the line.

In addition, the user may specify that the LanScan START, CENTER, STOP, or START CONTINUOUS trace at the triggering event: START means that the LanScan will capture data which follows the triggering event, and that the data will be held in store for the user to scroll through and analyze; CENTER causes the LanScan to capture half of its data before the triggering event and half of its data after the triggering event, and to hold the data in store for the user to scroll through and analyze; STOP specifies that the monitor capture data until the triggering condition is detected, and then to hold the data in store for the user to scroll through and analyze; and START CONTINUOUS causes the monitor to display data packets which follow the triggering event immediately upon capturing them, and then to discard them -- in other words, packets simply scroll off the screen.

The Monitor also presents the packet data to the user in an appropriate form, by means of a parameter that allows the user to specify the family of protocol he or she is using (ISO, XNS, IP, or HEX); the Monitor then automatically interprets packets according to that protocol. If the HEX protocol is selected, all data in the packets is represented as Hex bytes; there is no protocol interpretation.

Finally, Traffic Generation Mode allows the user to generate traffic on the network and subsequently to monitor the number of packets sent, collisions detected, and transmissions deferred.

Conclusion

With the thousands of feet of cable now being installed in

buildings to support local networks, cable testers and node emulators are necessary to ensure a working cable plant. Also, after initial installation, obtaining good network performance requires management and maintenance. For the TDR user, this means keeping in mind the fact that impedance changes along the cable will inhibit network throughput. To minimize these changes -- or to correct them -- the user must interpret the TDR CRT readout and locate and repair the affected hardware. Damaged or faulty LAN components can include misinstalled transceivers, abraded or kinked cable, non-conforming connectors, etc.

When and if impedance changes can be diagnosed, the user may very well be saved from having much larger network problems later on. If impedance changes go undetected, the addition of new nodes to a LAN may result in problems on the network becoming visible. The simple assumption is that the last item added to the network -- the nodes in this case -- is the cause of the problem -- but in many cases this assumption is erroneous: what in fact is happening is that older problems that have previously gone undetected are now rearing their heads due to increased traffic levels and demands on the network.

Thus, the early and regular use of a TDR will help prevent any smaller faults from becoming bigger: it is far simpler to find a problem on a network with 10 nodes than it is to detect that same problem after 100 nodes have been added.

LAN monitors carry the network testing from the physical level to the data link level. Sophisticated, relatively low-cost monitors are becoming readily available. But while monitors keep managers updated on network "phenomemon," they often are unable to describe problems and can usually only suggest that problems may or may not exist.

On a local area network, problems may stem from physical, hardware, and software causes, and thus a comprehensive and effective LAN management policy should include the use of all of the different types of testing capabilities -- TDR, Node emulator/tester, and LAN monitor. The TDR and node emulator/tester are invaluable tools to guarantee correct operation of the network at the physical and access method levels, and once the physical network has been validated, the LAN monitor can be used to effectively test and isolate problems due specifically to software malfunctions. The equipment cost for all of these devices is close to $20,000, but in comparison to a network worth 100 times that amount, this kind of testing capability is modestly priced.

For more information on the products mentioned in this Special Report, contact Craig Benson, Cabletron, P.O. Box 6257, East Rochester, NH 03867, (603) 332-9400; Steve Gibson, Communication Machinery Corporation, 1421 State Street, Santa Barbara, CA 93101, (805) 963-9471; Donna Keeling, Excelan, 2180 Fortune Drive, San Jose, CA 95131, (408) 434-2237; Jennie Borchert, Riser-Bond Instruments, 505 16th Street, Aurora, NE 68818, (402) 694-5201; Stephane Johnson, TITN, 5591 W. 78th Street, Edina, MN 55435, (612) 944-5440.